NEW RECORDS OF DISJUNCT ARCTIC-ALPINE PLANTS IN MONTANA

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Two recent studies dealing with Montana alpine vegetation (Bamberg, 1964; Pemble, 1965) have produced new records as well as significant range extensions for several species representing a major floristic element in the alpine flora of the state, namely the arctic-alpine element. Four of these species which fill gaps in previously reported distributions are: *Festuca baffinensis* N. Polun., *Juncus albescens* (Lange) Fern., *Juncus biglumis* L., and *Kobresia myosuroides* (Vill.) Fiori & Paol. Three other northern species have their southern limits in the Rocky Mountains within Montana. These are: *Cassiope tetragona* (L.) D. Don, *Dryas integrifolia* Vahl, and *Festuca vivipara* (L.) Sm.

FESTUCA BAFFINENSIS N. Polun. probably has a circumpolar distribution (Holmen, 1964) though Tolmachev (1964) does not believe that any of the Eurasian Arctic material can clearly be referred to a taxon separate from *F. brachyphylla*. In the Arctic *F. baffinensis* has a continuous distribution from Alaska across Canada to northeast Greenland, preferring areas with calcareous soil. It has also been recorded from Svalbard and Novaya Zemlaya (Holmen, 1964). The species is known from isolated stations in the Rocky Mountains as far south as Colorado (Weber, 1961) and Wyoming (Johnson, 1962). Hultén (1962) suggests the probable presence of the species in northwest Montana although no specific stations are indicated from the state. Our collections were made in Glacier

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[2]We are indebted to the National Science Foundation for financial support of our studies. The senior author was supported under NSF Grant #11568 to the University of Montana and #23317 to the University of California, Davis while the junior author was aided, in part, by a National Science Foundation Summer Fellowship for Teaching Assistants.

National Park, one at Siyeh Pass (8 Aug. 1964, *Harvey & Pemble 7135*, MONTU) and one on Mt. Henry (15 Aug. 1964, *Pemble & Harvey 128*, MONTU).

JUNCUS ALBESCENS (Lange) Fern. is regarded by Hultén (1962) as a Greenland-American, eastern Asiatic race of the circumpolar-montane *J. triglumis* L. Polunin (1959) indicates that *J. triglumis* and *J. albescens* form a circumpolar series, hybridizing where their ranges overlap. *J. albescens* has been reported from Wyoming (Johnson, 1962) and Colorado (Harrington, 1954). *J. triglumis* has been reported from New Mexico (Wooton & Standley, 1915) and from Utah (Tidestrom ,1925) although these early reports should be referred to *J. albescens* according to Fernald (1924). An early collection referred to *J. triglumis* was made in northwestern Montana and reported by Rydberg (1900). The occurrence of *J. albescens (J. triglumis)*, previously suspected in Montana (Booth, 1950), is confirmed by two collections made in Glacier National Park, one at Siyeh Pass (3 Aug. 1963, *Bamberg 825*, COLO), and a second at Logan Pass (2 Aug. 1960, *Schofield*, MONTU *51409*).

JUNCUS BIGLUMIS L. is considered by Polunin (1959) and Hultén (1962) to be a fully circumpolar species. Hultén's distribution map for the species shows disjunct stations in Colorado, where the species was reported by Weber (1955), and near the Beartooth Plateau in Wyoming. Two Montana collections of this species have been seen, both from Logan Pass in Glacier National Park (2 Aug. 1960, W. B. Schofield, MONTU *51397* and 21 Aug. 1962, *F. J. Hermann 18123*, MONTU). This species has not previously been reported for the state but Dr. F. J. Hermann has given us permission to publish the report of his collection from Glacier Park.

KOBRESIA MYOSUROIDES (Vill.) Fiori & Paol [*K. bellardii* (All.) Degl.] is considered by Hultén (1962) to be circumpolar arctic-montane species with a continuous distribution from the North American Arctic south to the international border. From there the species is disjunct with stations in the Wallowa Mountains of Oregon (Peck, 1961), the Beartooth Mountains of northwest Wyoming (Johnson ,1962), Colorado where it occurs on scattered peaks (Harrington, 1954), Utah in the Unita Mountains (cf. Major & Bamberg, 1963) and New Mexico (Wooton & Standley, 1915). In addition, Major and Bamberg (1963) have reported its occurrence at Convict Creek in the Sierra Nevada of California where it is found with four other disjunct cordilleran species. Our collections are from Glacier National Park (3 Aug. 1963, *Bamberg 797*, COLO) where the species occurs at Siyeh Pass.

CASSIOPE TETRAGONA (L.) D. Don is probably circumpolar, being abundant almost everywhere in the Arctic except towards the highest latitudes (Polunin, 1959). The species has been reported as far south as Okanogan Co., Washington on the Pacific Coast and Glacier National Park in the Rocky Mountains (Hitchcock *et el.*, 1959). Our collection of the species (27 Aug. 1965, *Pemble 254*, MONTU) was made on St. Mary Peak in the Bitterroot Mountains of western Montana about 175 miles south of Glacier Park.

DRYAS INTEGRIFOLIA M. Vahl ranges throughout the Arctic regions of the western hemisphere from western Alaska to East Greenland (Polunin, 1959), across much of Canada south to southern British Columbia and Alberta and east to Newfoundland with an isolated station near Lake Superior (Hultén, 1959). This species has been reported once from Montana (Porsild, 1947) although Hitchcock *et al.* (1961) indicate that they have seen no material of *D. integrifolia* from the state. As the determinations of our *Dryas* specimens were made by E. Hultén we are including the collections from the Big Snowy Range *(Bamberg 313, 565, 769*, COLO) and from the Tobacco Root Mountians *(Bamberg 429*, COLO) which he referred to *D. integrifolia* ssp. *integrifolia* as confirmation of the species' presence in the state.

FESTUCA VIVIPARA (L.) Sm. is considered by Hultén (1958) to be a doubtful taxon with an uncertain geographical range. Its taxonomic status in the Eurasian Arctic has been questioned by Tolmachev (1964) who indicates that vivipary occurs in almost sporadic fashion throughout the area of *F. brachyphylla* and *F. ovina*. Hultén's distribution map for the species shows it to be common in the Scandinavian mountains, in south Greenland, and in Iceland. He also cites reports from Novaya Zemlaya and other places in Arctic Russia. Fernald (1950) considers it to reach from Greenland and Labrador to Alaska and south to west Newfoundland, Anticosti, Gaspé Peninsula and Lake Mistassini, Quebec. Holmen (1964) indicates that *F. vivipara* (L.) Sm. is, in the sense of most authors, a complex probably consisting of a number of species and hybrids. Different chromosome races are known to occur although the taxonomic status of these has not as yet been determined. He suggests on the basis of chromosome number ($2n = 28$) that the typical race includes the taxon common in the Scandinavian mountains, in Iceland, and South Greenland, and that the viviparous *Festuca* with higher chromosome numbers, occurring in other parts of the Arctic, is probably closer to *F. brachyphylla* or *F. baffinensis*. Johnson and Viereck (1962) have indicated that their material from Alaska should be referred to the same taxon as that in Scandinavia. We also feel that our collections may be referred to the Scandinavian populations on the basis of external morphology, but we have made no chromosome counts. Several collections of this species have been made from Glacier National Park including localities at Logan Pass (11 Aug. 1949, *L. H. Harvey 4030;* 2 Aug. 1960, *Schofield,* MONTU *51406;* 8 Aug. 1964, *Harvey & Pemble 7091,* MONTU) and Siyeh Pass (3 Aug. 1963, *Bamberg 819,* COLO; 8 Aug. 1964, *Harvey & Pemble 7145,* MONTU). These stations are considerably removed from the range shown by Hultén (1958) for the species in which the Alaskan stations are not included. If the Alaskan reports are included the gap extends from Alaska to the area of our present report in Glacier Park.

In addition to the seven species just discussed which belong to the Arctic flora two other extensions of alpine species are worth reporting here. *Carex stenochlaena* (Holm) Mack., previously known from Alberta and Alaska south to Washington and Idaho, was collected at Logan Pass in

Glacier National Park by F. J. Hermann (26 Aug. 1962, *F. J. Hermann 18300*, MONTU) who has given us permission to include it as a new Montana record. A second interesting range extension is that of *Saxifraga tolmiei* T. & G. which is a typical member of the Pacific Coast-Cascade flora. This species was previously known in Montana only from St. Mary Peak in the Bitterroot Mountains although it is distributed along the Pacific Coast from Alaska south through the Cascades and Sierra Nevada of California (Hitchcock *et al.*, 1961). Additional Montana collections of this species were made on Trapper Peak (25 July 1964), *Pemble & Harvey 58*, MONTU), a southern extension of 50 miles, and in the Highland Mountains south of Butte, Montana, an eastern extension of approximately 80 miles.

Disjunctions, which are common in Arctic and alpine plant species, are of interest to those concerned with the floristic history of any region. Such disjunctions may also have environmental causes. The disjunctions we have noted suggest a discussion of some recent phytogeographical work along these lines.

Weber (1949, 1959, 1965) proposes that in the southern Rocky Mountains the richest alpine communities in terms of the Arctic relicts that they harbor are found in the most mesic areas, particularly where high ranges trending east-west lie between or connect the principal north-south ranges. In such ranges diurnal insolation through the summer months is less direct or of shorter duration, resulting in small bogs and lakes at high elevations. He indicates that the rare species may occur on either north- or south-facing slopes as well as in cold-air drainage basins. Johnson (1962) suggests that the disjunct occurrences of thirteen species in the Beartooth Mountains of Wyoming may be attributed to one of two factors: (1) that the bog environments are capable of dissipating the excessive summer heat allowing certain arctic-alpine relicts to persist, (2) that other arctic-alpine species can persist in the unstable environment of solifluction slopes. Dahl (1952, 1955) has pointed out that in Scandinavia the isotherms of the average yearly maximum summer temperature at the highest points of the landscape coincide closely with the distribution limits of a large number of arctic-alpine species. The importance of temperature is difficult to analyze in the Rocky Mountain alpine areas where high altitude weather stations and climatic data are scanty.

Fernald (1907) regarded the southern distribution of alpine species in eastern North America to be a function of the amount of calcium or potassium in the soil. In criticizing the "nunatak theory" later proposed by Fernald (1925), Wynne-Edwards (1937, 1939) suggested that most isolated occurrences could be better correlated with soils, particularly those rich in lime or combinations of magnesium, lime and soda, than with the presence or absence of Wisconsin glaciation in a particular area. Rune (1953) has proposed that the main soil factor involved in the distribution of alpine plants in Scandinavia appears to be the degree to which the humus colloids are saturated with cations, predominantly calcium ions.

In Montana, five of the seven arctic-alpine disjuncts occur in Glacier National Park on substrates derived from limestone and argillites of the Belt Series. This produces a clayey soil high in calcium. *Dryas integrifolia* in the Tobacco Root Mountains also occurs on mixed metamorphics where lime is present. *Cassiope tetragona* which was collected in the Bitterroot Mountains occupied a depressional area where snow often persists late into the summer, however the nature of the substrate was not determined. Intrusive igneous rocks predominate in the area although the possibility of a limestone outcropping is not ruled out. Tentatively we would say that the species has persisted in this locality due to conditions of the habitat such as those described by Weber (1949, 1959, 1965).

Langenheim (1962) reports the occurrence of populations of certain disjunct arctic-alpine species in Colorado on metamorphosed limestones along a contact of intrusive igneous rocks while others occurred along a contact between metamorphosed sediments of siltstone. Major and Bamberg

(1963) found disjunct species in the Sierra Nevada of California occurring on soils derived from calcareous parent material in conjunction with non-calcareous metamorphics. However, they also point out the presence of other smaller areas of calcareous metamorphic rocks in the Sierra Nevada where none of the disjunct species have been found, suggesting that there is no one-to-one correspondence here between edaphic specialization and floristic distinctiveness. They also point out the fact that their disjunct species are indifferent outside of the Sierra Nevada as far as calcicoly is concerned. According to Bamberg (1964), and as the work of Mooney & Billings (1961) confirms, many of the wide-ranging arctic-alpine species have northern and southern ecotypes.

In reviewing the literature dealing with disjunct or relict populations of arctic-alpine species it becomes obvious that such distributions cannot be attributed to any one factor. First, it is necessary to classify disjunct species as to their ecology throughout their continuous range of distribution as well as in the disjunct locality. We can then see how a population of *Festuca baffinensis*, found in open wind-swept areas in the Arctic, might persist in similar alpine situations, while such a locality does not harbor species of considerably different ecological requirements such as *Cassiope tetragona*, normally restricted in the Arctic to areas of snow accumulation. With this in mind we can next consider climatic limitations or edaphic specialization noting, for example, that soils high in calcium, or calcium and clay, such as the Montana localities previously discussed, are in fact often correlated with disjunct arctic-alpine species provided the first criteria is satisfied. It is also not unexpected that other relict species are found where contact areas in the substrate provide a unique edaphic situation satisfying the nutrient requirements of the relict species persisting there.

Gankin and Major (1964) have reviewed the problem of disjunct populations, and suggested that their presence may often be attributed to limited competition resulting from failure of the local, zonal vegetation to fully occupy the site.

This in turn is often correlated with an unusual edaphic situation. Contrary to this observation are our disjunctions of *Festuca baffinensis* or *Cassiope tetragona*. The former occurs on open sites in Glacier Park as well as in Colorado (Weber, 1961) where competition from zonal vegetation is not a factor while the latter occurs intermixed with a luxuriant growth of zonal vegetation, *Cassiope mertensiana*, suggesting that it is not limited to the relict site by competition. It is suggested that while a correlation between disjunct or relict populations and local vegetation in an azonal state may exist at lower elevations, such a relationship does not necessarily apply to all alpine situations where Arctic relicts occur.

Climatic conditions may be of importance directly, such as prohibitive maximum summer temperatures as suggested by Dahl and Johnson, or indirectly as they have modified a potentially suitable relict habitat. Thus, in analyzing disjunct and relict situations we should be prepared to correlate the presence of the disjunct relict species not with one but with several factors of the ecosystem which may interact and thus provide the necessary habitat suitable for its persistence.

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